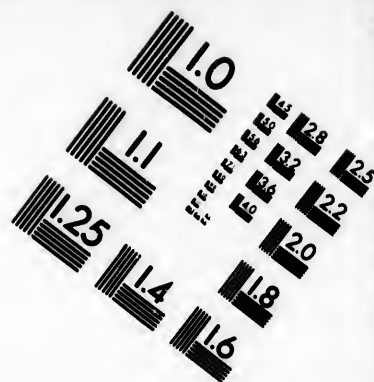


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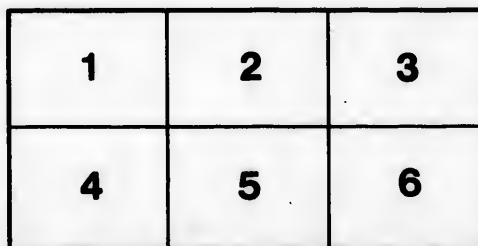
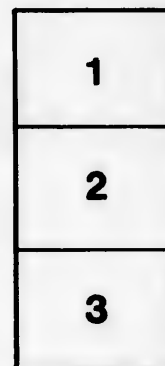
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Canadian Society of Civil Engineers.

INCORPORATED 1887.

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THE DISCHARGE OF THE ST. LAWRENCE RIVER.

BY PROF. C. H. McLEOD, M.A., M.CAN.SOC.C.E.

Read at Toronto Meeting, June 18th, 1896.

The extreme low water of the St. Lawrence in the autumn of the past year called especial attention to the variations in the discharge of the river, and it seemed to the writer to be a matter of no small importance to obtain a measurement of it at the exceptionally low stage existing in the early part of November.

From inquiry made at the time, it was learned that it was not the business of anyone in Canada to gauge the St. Lawrence, and that the only measurement ever made below Montreal was that by Mr. W. J. Sproule, M.Can.Soc.C.E., under the direction of the Montreal Flood Commission, in 1886. Having in view the interest of a measurement at this special time, and as the work happened to fall into line with one of the courses of Surveying lectures then in progress in McGill College, the writer induced some of the students of the University to undertake the work under his direction, assisted by Prof. C. B. Smith, M.Can.Soc.C.E., and Mr. J. G. Kerry, A.M.Can.Soc. C.E. The Hon. G. A. Drummond very kindly placed his private yacht at the disposal of the college for the purpose, and Mr. Frank Redpath gave up two days of his valuable time to take charge of the yacht during the work.

The position chosen for the gauging is situated about forty miles below Montreal, its upper limit being approximately 6,200 feet below the wharf on the north shore of the river, at Lanoraie. This choice was made not only because it is the position best suited for the work within easy reach of Montreal, but also chiefly for the purpose of comparison with Mr. Sproule's work, the position being that in which his measurements were made.

It was intended that the gauging should be made during the first week in November, but owing to unavoidable circumstances it had to be postponed, and was not made until the 13th and 14th of the month. Reference to diagram No. 11 will show that the lowest water levels in 1895 occurred on Oct. 28th, Nov. 2nd and 7th. On the first day of the measurement, Nov. 13th, the water level was seven inches above its lowest point, and it rose three inches while the work was in progress.

For a mile or more both above and below the gauging area, the river runs a straight course and has a very uniform cross section. Over this distance also, the levels which were taken under the direction of the Flood Commission in 1886 showed a constant surface slope.

In order that the measurements might be entirely comparable with those of Mr. Sproule, similar methods to those employed by him were adopted. The velocity observations were made on rod floats immersed to the greatest possible depths. In the reduction of the work, the ob-

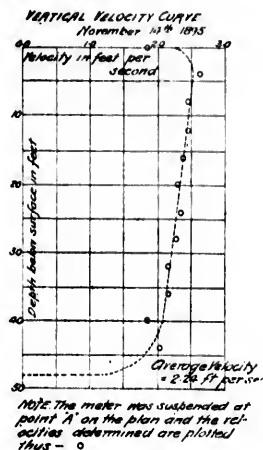
served velocities were corrected by reference to a vertical velocity curve obtained from measurements with an electrical current meter, by Amster, see page —. The rods were of uniform section, and were loaded with lead weights within tin cylinders, having the same section as the rods. The immersed depths of the rods, as will be seen on the accompanying plate No. 10, ranged from 6 feet to 42½ feet. The average velocities were obtained from the times of crossing of the two ranges, and were checked by the velocities between the stations along the lines, the positions of which were fixed by box sextant angles to points on the shore. All data as to soundings were, through the kindness of Mr. John Kennedy, taken from the plans of the Montreal Flood commission.

The plate No. 8 shows the contour lines of the river bottom and shore lines for the length of 3000 feet, over which the float observations were made. It shows also the courses of the several floats, with their observed velocities and the immersed depth of each float. The plate No. 9 gives similar information for Mr. Sproule's measurements. The plate No. 10 shows the average cross sections for the entire length of 3000 feet. The upper section refers to the work in 1886 and the lower one to that in 1895. The mean position and lateral range of each float is also represented on the diagrams. The dotted lines below represent the most probable velocity curves resulting from the observations. In both cases the plotted velocity curve is that which results from the float observations, after applying the small correction due to depth of immersion, as compared with the average depth of the water along its path. This method of reduction gives, of course, slightly smaller values than those arising from the observed velocities, and the discharge as here computed for 1886 is somewhat less than the official figures of the Flood Commission. The area of the cross section in 1886 was 115,298 square feet, and the discharge 311,101 cubic feet per second. The area of the 1895 cross-section—when the water was one foot nine inches below official low water—was 105,432 square feet, and the discharge amounted to 216,621 cubic feet per second. At the period of lowest low water in 1895, in which the water level was, as nearly as can be ascertained, two feet seven inches below official low water, or corresponded to a depth of seven feet eleven inches on the flats of Lake St. Peter, and 24.9 feet minimum depth in the navigable channel of the river, the cross section was reduced about two per cent. below that of Nov. 13 and 14, 1895. Assuming that the discharge of the river varies proportionally to the area of the cross section, and taking as data the results of the measurements above given, the discharge at the lowest water stage of 1895 amounted to about 196,000 cubic feet per second.

Referring now to the degree of accuracy which should be expected in work of this kind, the positions of the lines I, III, VII, VIII, X, XI, XIV and XV, Plate No. 8, will be found to accord somewhat closely with those upon which the 1886 discharge depends. The additional lines in groups near to some of these afford an excellent means of estimating the limits of precision of such measurements. The lines V, VI and VII were practically in the same position and the rods were all immersed to the depth of 42 feet, yet there was a difference in the average velocities of two of the rods of 13-100ths of a foot per second, amounting to over six per cent. of the whole velocity. The two lines which show the extreme velocities 2.07 feet per second and 2.19 feet per second were run within a few minutes of each other and under precisely similar conditions, on the morning of the second day of the work, with a strong wind blowing at right angles to their directions, whereas No. VII was run on the previous day during very calm weather. It is perhaps worth noting that although about 10 per cent. of the length of the poles projected above the water surface, there was no appreciable drift in the lines.

A similar, but not quite so great discrepancy occurred in the velocities of the rods IX and X. There the difference amounted to about 5 per cent. of the whole.

The writer cannot but confess to some surprise that under conditions so very favourable to uniform motion in the vertical filaments of water, such great discrepancies as these should be found.



In the above diagram the vertical velocity curve resulting from the measurements by meter at the position marked (A) on the plate 8 is exhibited. The velocities at the several depths are the averages of two independent measurements extending over about three minutes each. The velocities at the surface and at the 4 feet depth are discordant, owing to their proximity to the yacht. Similarly, the variations in the two lower positions arise probably from deflected currents due to irregularities in the bottom. The average velocity given by the curve agrees very closely with that which would be obtained from a float passing through this position. Owing to lack of time it was impossible to obtain more than one set of measurements, and this curve has been taken as a typical one in the reduction of the work.

Great difficulty has been experienced in this work in ascertaining definitely the elevation of the water, owing to some uncertainty as to the setting of the Sorel gauge and also as to the reading on it which corresponds to low water. The gauges should of course be referred to permanent bench marks, which have themselves been established from an accurate line of levels referred to one datum plane. The bench marks in connection with the Montreal Flood Commission were not intended as permanent points of reference, and some of them, notably that at Sorel itself, is unfortunately unreliable. Lines of levels have been run on both banks of the St. Lawrence by Mr. Steckel of the Department of Public Works, but the author is not aware that the gauges have been established in connection with these.

Plate No. 11 gives the relative water levels in 1886 and 1895 as nearly as the writer has been able to obtain them. There is an uncertainty amounting to about 10 inches.

The great question of the causes which lead to so phenomenal a low water period is one which the author has at present not had time to discuss. He is, however, glad to state here that it has recently been the subject of a paper by Mr. Stupart, director of the Meteorological Service, an extract of which referring to the low water period under consideration may perhaps be quoted:—

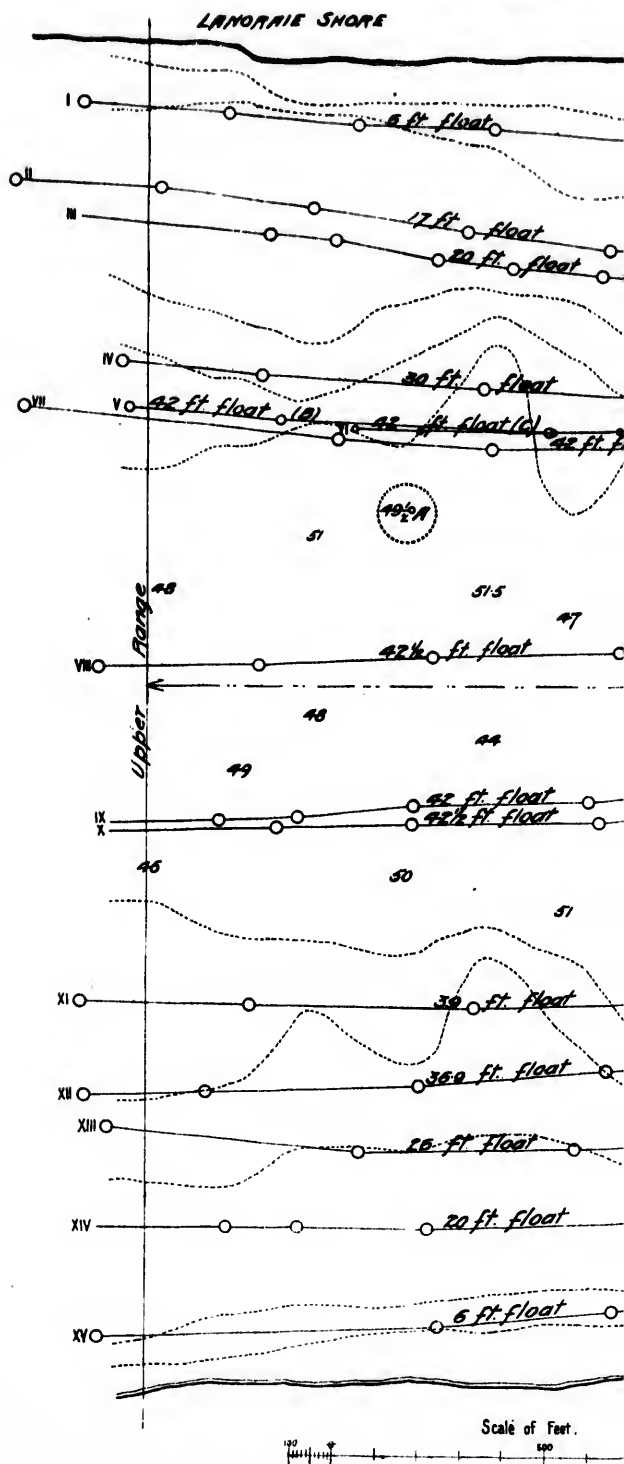
.....“ We can now see why Lake Huron is so decidedly low, it is due to Lake Superior having been low for some years until 1894, combined with the effect of an abnormal deficiency of rainfall from 1887 to 1895, excepting the years 1892 and 1893. At the beginning of this same period in 1887, Lake Ontario was high, but two years of exceedingly small rainfall rapidly lowered the level. In 1889 and 1890, the rainfall was above average, and temporarily checked the fall which would

have resulted from the low water in the Upper Lakes ; but in 1891, a marked deficiency of precipitation brought a very low winter stage. Two years, 1892 and 1893, of above average rainfall now improved the level a little, but the deficiency of rainfall in 1894 and 1895, and particularly in the latter year, in conjunction with the effect of a small intake of water by the Niagara River, doubtless produced the almost phenomenally low stage of the past year. I believe that these facts are amply sufficient to explain the present state of affairs.....
.....In view of these facts it is quite unreasonable to suppose that Lake Ontario will, this year or even next year, attain a high stage, the increase is likely to be gradual. Lake Superior is, as we have seen already, high ; this will help to raise the level of Huron, which lake will rise if the rainfall be even up to the average, and then with an improving head of water in that lake, and consequently in Erie, the flow by the Niagara will improve and assist in raising the level of Ontario ; but with so many factors to be considered, it is impossible to predict with any certainty how long it will be before a really high stage is again reached."

THE DISCHARGE

PLAN SHOWING FLO

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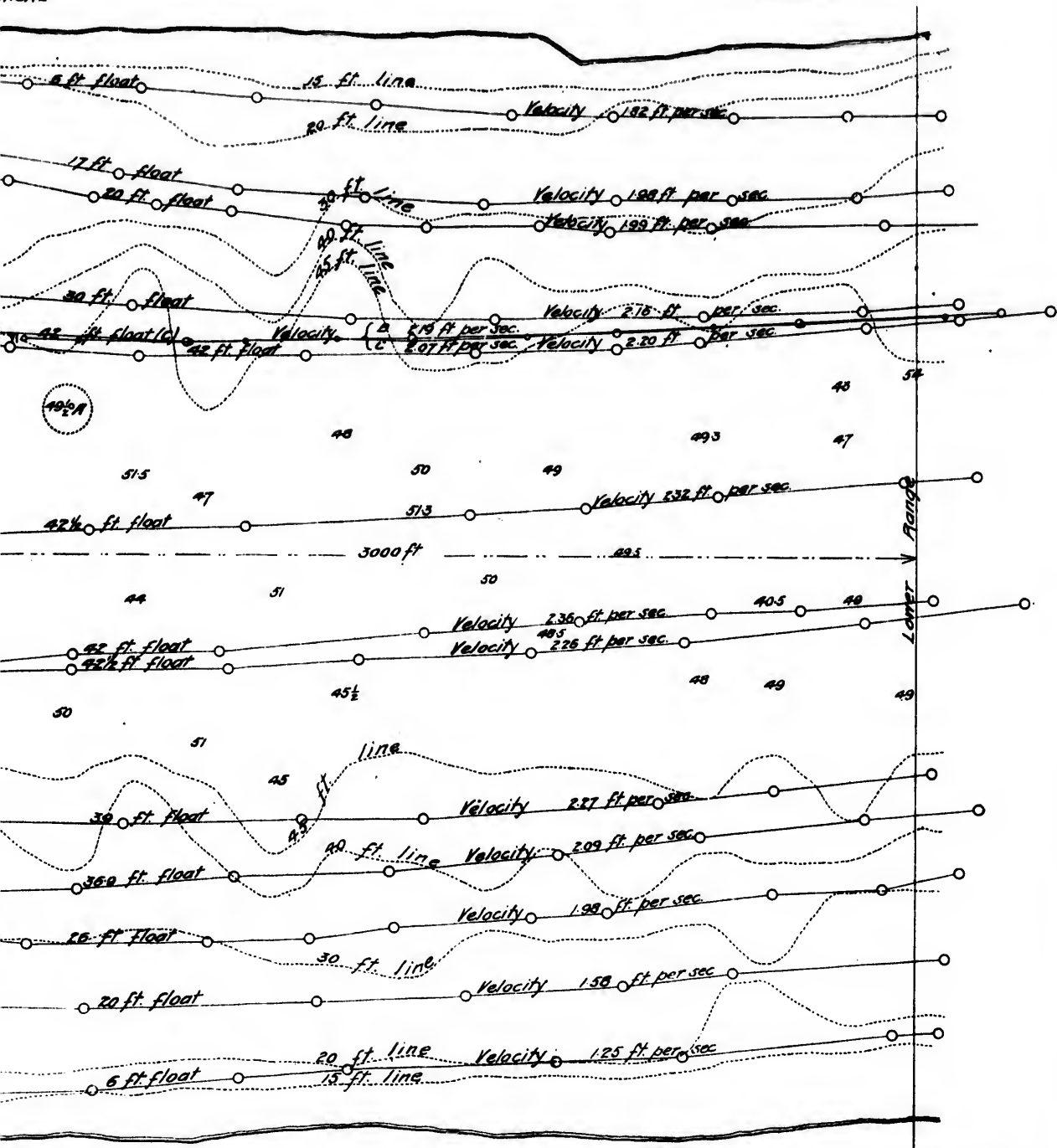
THE DISCHARGE OF THE ST LAWRENCE RIVER

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MCGILL UNIVERSITY - NOVEMBER 13TH AND 14TH 1895

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C. H. M'LEOD

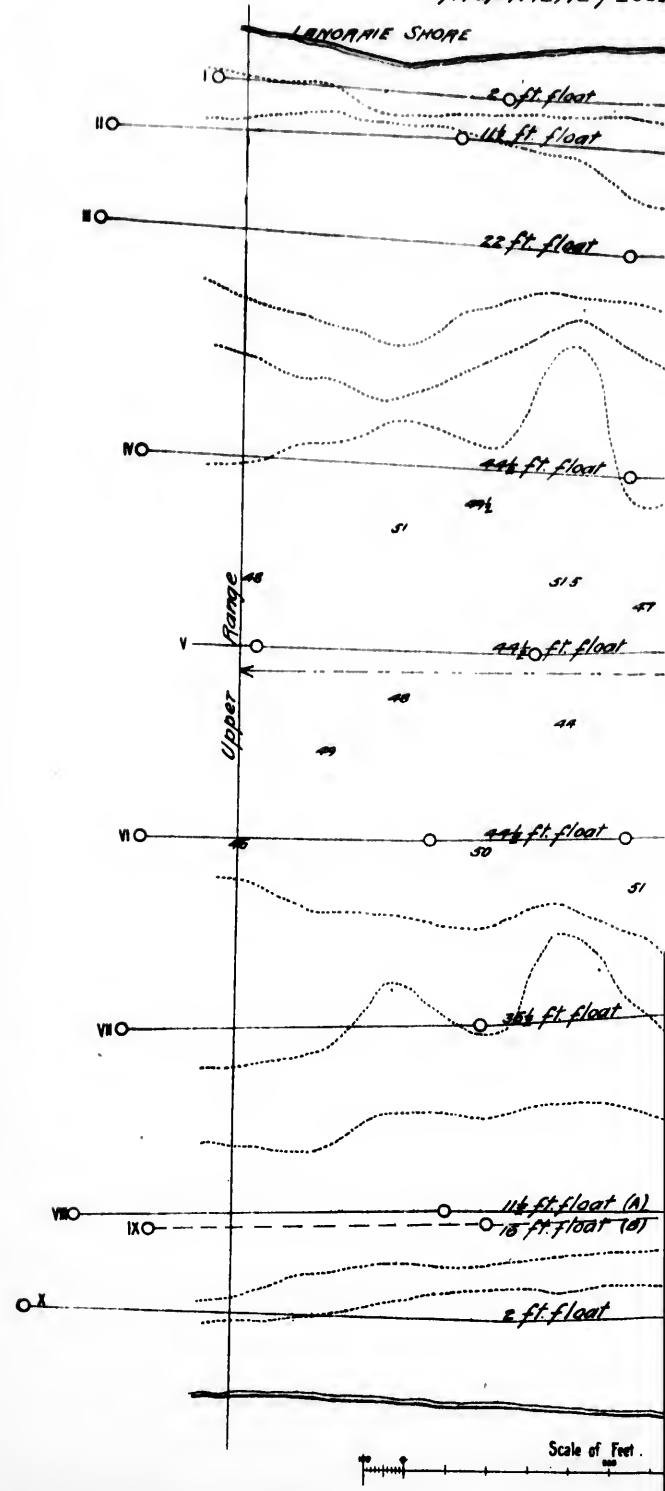


NOTES. Observed positions of floats are marked thus: ○
 The lines of equal depth are drawn for water at
 10' 6" on the flats of Lake St. Peter

THE DISCHARGE

PLAN SHOWING

MONTREAL FLOOD

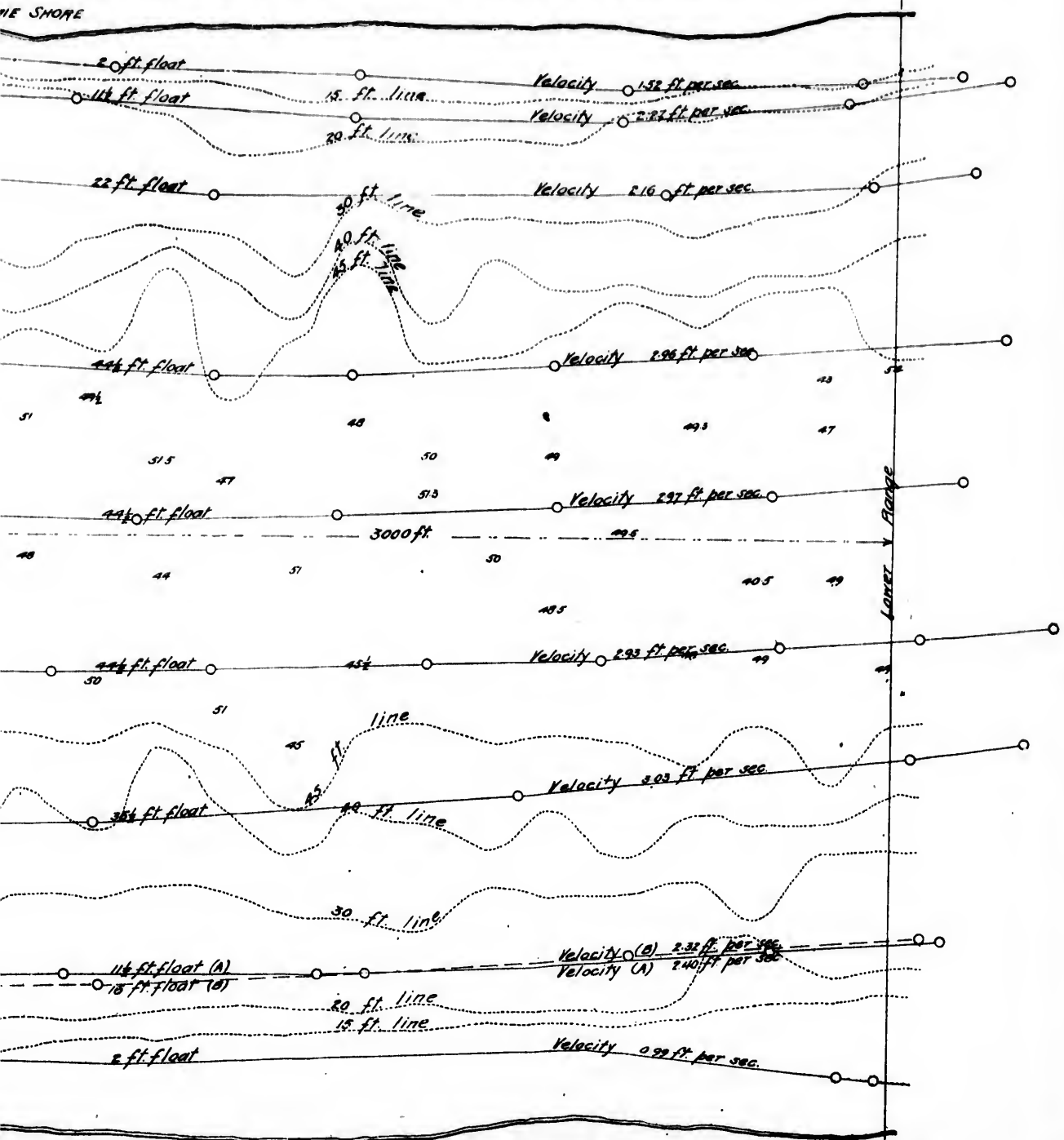


THE DISCHARGE OF THE ST LAWRENCE RIVER

PLAN SHOWING FLOAT LINES AND LINES OF EQUAL DEPTH

MONTREAL FLOOD COMMISSION - NOVEMBER 2ND AND 3RD 1886

C. H. MILEOD

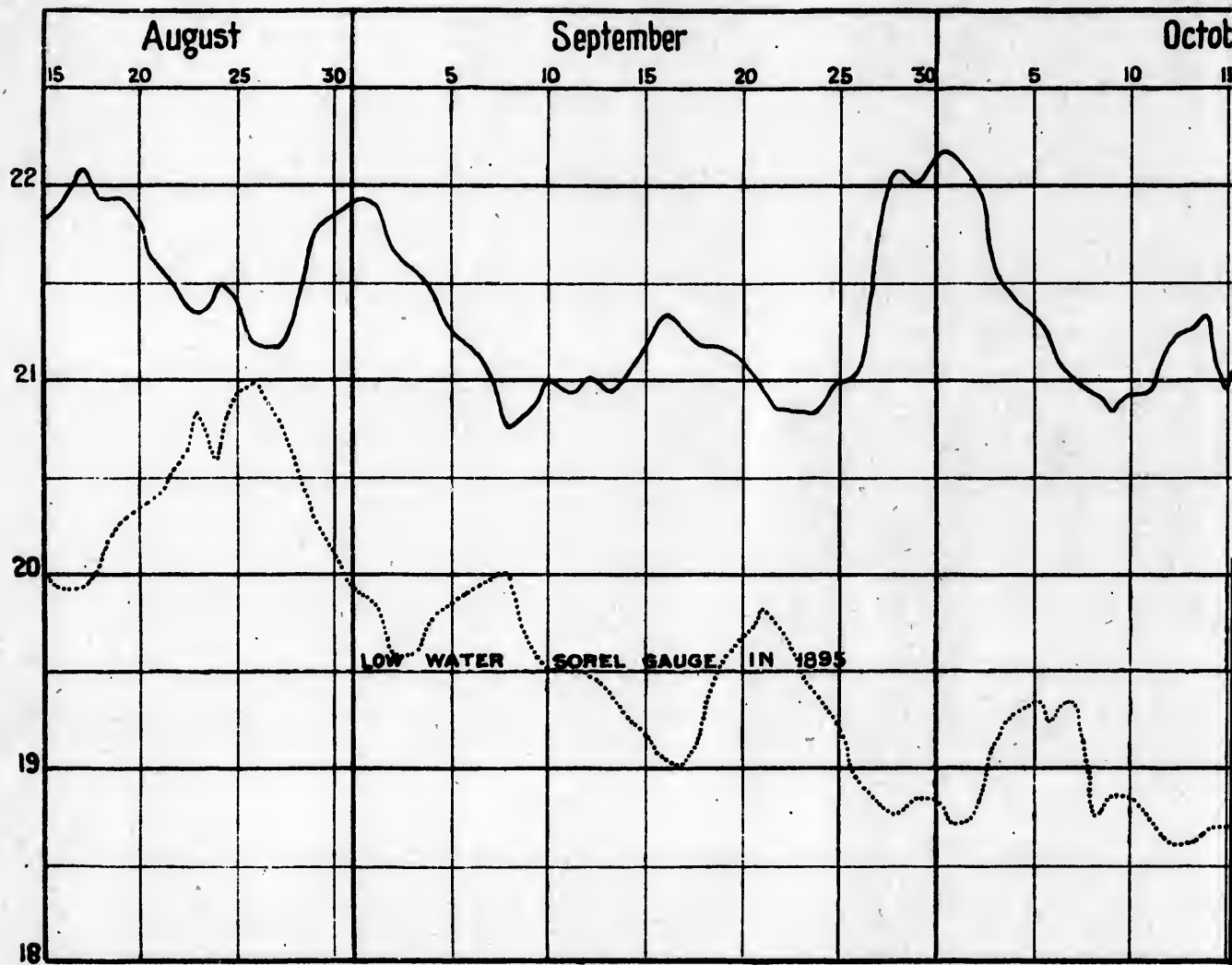


Notes. Observed positions of floats are marked thus: ○

The lines of equal depth are drawn for water at 10'6" on the flats of Lake St. Peter

Reference.
 1886 Readings shown ————
 1895

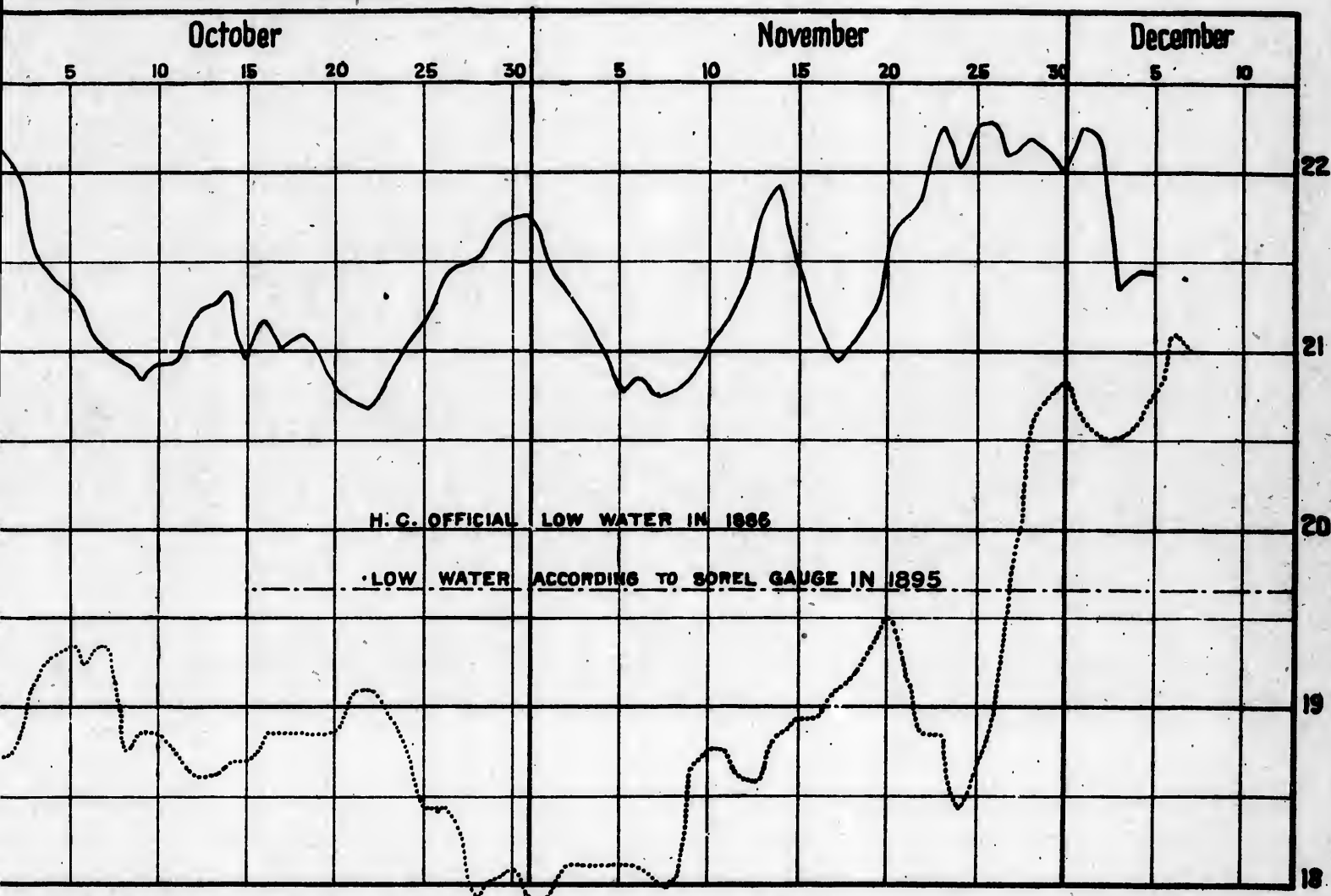
THE DISCHARGE OF THE
 Diagram of the Readings
 in 1886 and



NOTE. - Official Low Water corresponds to a depth of 27'-6" in to 10'-6" on the flats of Lake St Peter.

DISCHARGE OF THE ST. LAWRENCE RIVER
*of the Readings taken on the Sorel Gauge
in 1886 and 1895.*

C. H. McLEOD



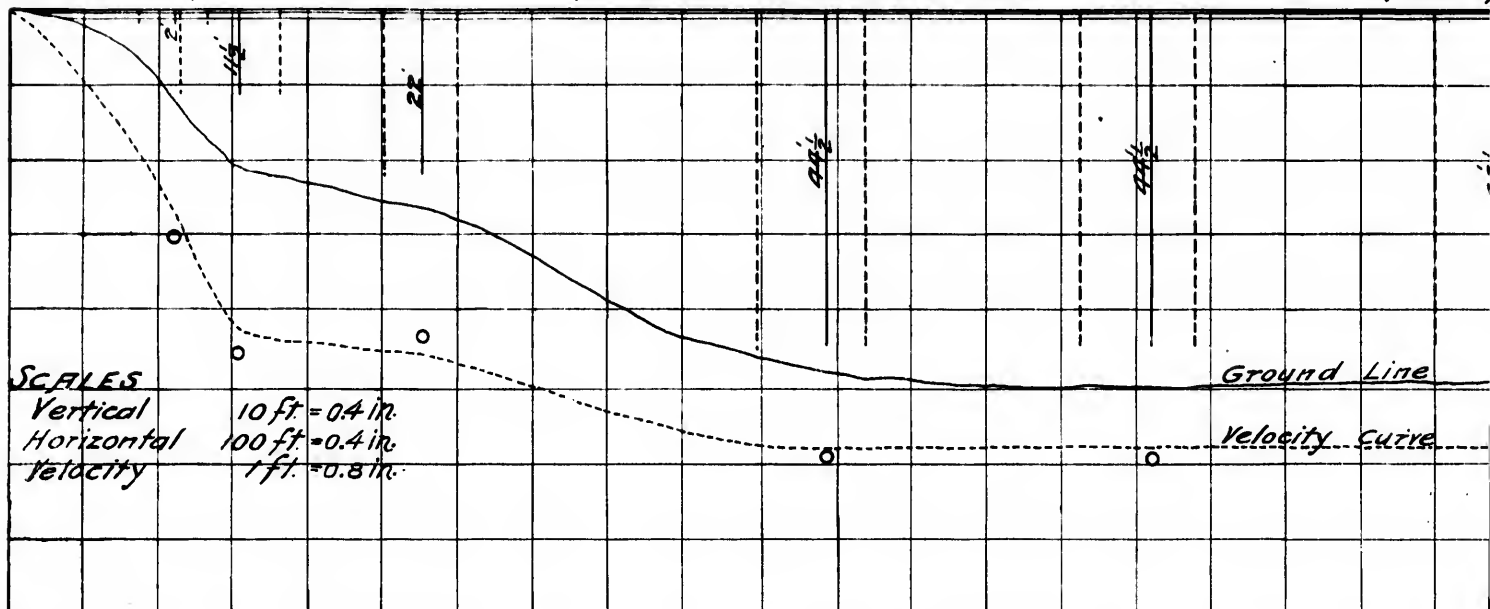
ds to a depth of 27'6" in the Ships Channel which is supposed to be equivalent

THE DISCHARGE OF THE AVERAGE CROSS SECTION SHOWING LATERAL MOVEMENT OF FLOAT

Montreal Flood Commission

November 2nd and 3rd 1886

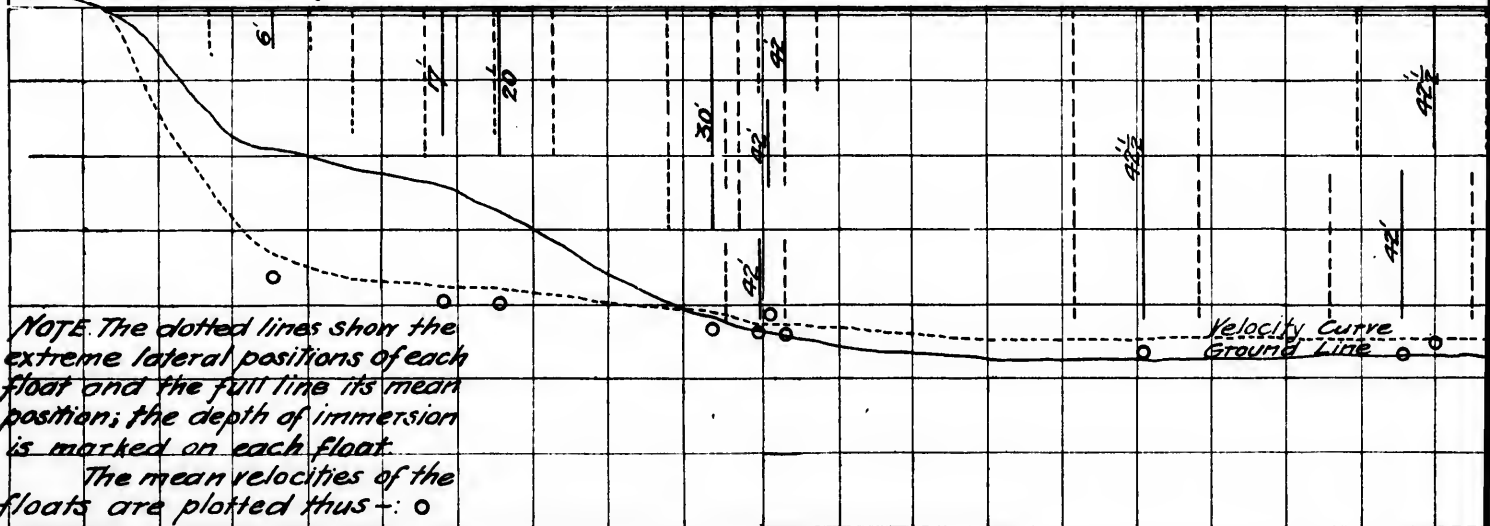
Water 11'-9" on flats of



McGill University

November 13th and 14th 1895

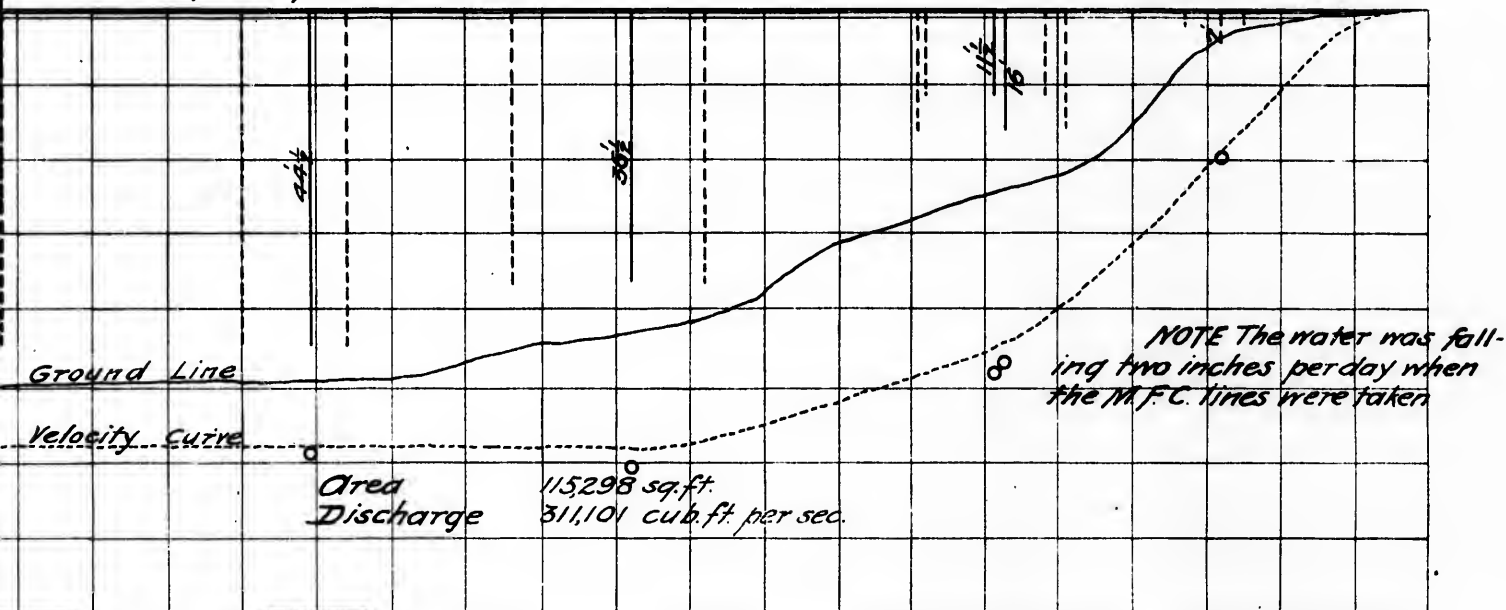
Water 8'-9" on flats of



OF THE ST LAWRENCE RIVER MOVEMENT OF FLOATS AND ESTIMATED CURVE OF MEAN VELOCITIES

C. H. McLEOD

r 11'-9" on flats of Lake St. Peter



r 8'-9" on flats of Lake St. Peter

